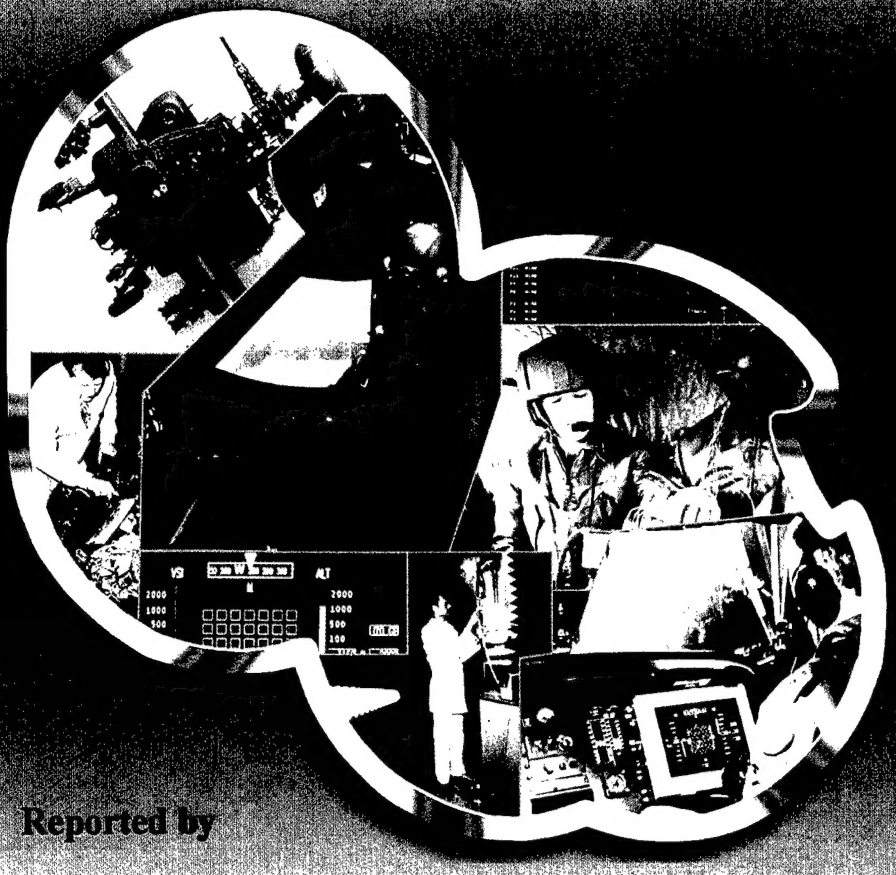
U.S. Army Aeromedical Research Laboratory

Annual Progress Report

Calendar Year 2001



Reported by

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March 2002

U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

USAARL

U.S. Army
Aeromedical Research
Laboratory

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Annual Progress Report gives the calendar year 2001 personnel and funding strength of the U.S. Army Aeromedical Research Laboratory. This report includes an overview of the Laboratory activities, current areas of research, and a brief description of the research being conducted.

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BACKGROUND

The U.S. Army Aeromedical Research Laboratory (USAARL) was established in 1962 to accomplish research in support of Army aviation and airborne activities, and to provide a central aeromedical research and reference library. In 1974, medical research programs in acoustics and vision were added to the Laboratory's mission. USAARL's mission was further expanded in 1977 to include the assessment of health hazards and research in support of both air and ground vehicles and weapons systems. In spite of this mission expansion, USAARL's primary mission remains medical research support of Army aviation.

Scientists and engineers assigned to USAARL seek to enhance force effectiveness by preventing or minimizing health hazards created by military systems, doctrine and tactics. Specifically, they identify, investigate and solve medical and health-related problems which deter soldiers/aviators from performing their mission or compromise their safety. Co-location with the U.S. Army Aviation Center allows USAARL's unique mix of scientific personnel to successfully conduct critical research for solving operational medicine problems for our aviators. Additionally, USAARL provides military developers with information and expertise to enhance the performance and safety of future Army systems.

USAARL maintains close coordination with other services and the international allied medical research community as a member of the North Atlantic Treaty Organization (NATO) Research and Technology Organization (RTO); the Air Standardization Coordinating Committee, Aerospace Medical and Life Support Systems; and the Triservice Aeromedical Research Panel (TARP).

This report presents an overview of USAARL activities during calendar year 2001 (CY01), identifies current areas of research, and gives a brief description of the research programs being conducted.

MISSION

USAARL conducts research and development on health hazards of Army aviation, tactical combat vehicles, selected weapons systems, and airborne operations. Assesses the health hazards from noise, acceleration, impact, and visual demands of such systems and defines measures to offset hazards. Assesses stress and fatigue in personnel operating these systems and develops countermeasures. Assists in development of criteria upon which to base standards for entry and retention in Army aviation specialties. Assists other U.S. Army Medical Research and Materiel Command (USAMRMC) laboratories and institutes research on the impact of continuous operations on individual and crew performance and development of improved means of patient evacuation. Assesses current life support equipment to identify causes of failure and devises improved design. Assists the combat developers and materiel developers of new Army aviation and tactical combat vehicle systems to recognize and eliminate health hazards as early as possible in the developmental cycle. Conducts collaborative research with other Department of Defense and federal agencies on medical research and development issues of common concern.

U.S. Army Aeromedical Research Laboratory--Calendar Year 2001

FROM THE COMMANDER

The U. S. Army Aeromedical Research Laboratory (USAARL) is proud to present this summary of achievements for calendar year 2001. Our personnel made significant contributions to Army readiness this year through the continued accomplishment of our research mission.

Sleep deprivation, fatigue, reverse cycle shifts, and other work-related stressors degrade aviator performance, potentially causing serious problems with regard to safety and effectiveness. In order to analyze when aviators work, how frequently they rotate shifts, and how well they sleep when working nights, a survey was performed to address the effects of reverse cycle.

USAARL life support equipment researchers discovered a discrepancy in the shell of the recently-fielded HGU-56/P aviation protective helmet. This discovery expanded to a review of local Army aviation assets, as well as an Army-led quality control assessment of manufacturing techniques. Further, our engineers were instrumental in testing a new infantry boot and advising the Army regarding its fitness for use in the aviation environment.

Our Laboratory serves as the Army's primary site for assessment of night vision goggles in the Army aviation environment, and this year's assessment included a number of efforts. Studies were conducted to evaluate the Aviator's Night Vision Imaging System (ANVIS) heads-up display mock-ups on ANVIS compatibility and ANVIS performance. A project also was completed to determine the feasibility of using the AN/PVS-14 monocular night vision device for pilotage.

Cockpit air bag research has focused on determining the risk of facial and/or ocular injury due to night vision goggles being propelled rearward into a cockpit occupant's face by a deploying air bag. Our tests showed that eye injuries appeared to correlate with head acceleration rather than globe distortion or blunt trauma.

Eventually presbyopic changes force all aviators, even those who have never worn glasses or contacts, to use a correction in order to see their flight controls and read approach plates and maps. Single vision contact lenses only correct distance vision; therefore, the aging aviator must adapt to these changes by reverting to bifocal spectacle wear. USAARL is studying a new generation bifocal contact lens that could ultimately lead to recommended fitting procedures and clinical tests that might be relevant to determining the levels of visual performance required for flight.

Health hazards encountered in Army systems include whole-body accelerations and blunt impacts that can produce skeletal and internal soft tissue injuries. One way USAARL assesses these hazards is by using crash manikins and anthropomorphic test devices that faithfully reproduce the human biodynamic response to impact. When subjected to impact tests, data from these devices are processed and evaluated to estimate the risk of injury to the exposed soldier.

USAARL remains dedicated to the support of our customer, the combat soldier aviator. We are proud of the singular work we have accomplished on his/her behalf and dedicate ourselves to this continuing mission.

BRIAN S. CAMPBELL
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Commanding

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Aircrew Protection Div
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Miscellaneous Numbers

Charge of Quarters (24 hrs) (334) 255-6920/6936		Library (research)	6936
Budget	6842	Manpower Office	6840
EEO Coordinator	6827	MARS Facility	6990
Flight Simulator	(334) 598-5078	PSNCO	6886
		Training NCO	6940
		Visual Information	6934

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Callender Year 2001

PERSONNEL

As with the majority of organizations, USAARL continues to be impacted by downsizing within the Government. Loss of manpower authorizations and requirements, both military and civilian, deletes critical scientific skills and intensifies the disparity between required and authorized strength levels. In order to meet continuing mission demands in light of these staffing limitations, in addition to the work force described below, USAARL had 3 overhires, 5 terms, and a monthly average of 15 non-TDA personnel during CY01. Non-TDA personnel include Army student contractors, Army Research Office personnel present under the Summer Faculty and High School Math and Science Teachers Programs, and other on-site research and research support contractor personnel, exchange officers and casual officers.

Required strength was 31 officers, 2 warrant officers, 39 enlisted, and 78 civilians, for total requirements of 150. Authorized were 17 officers, 2 warrant officers, 30 enlisted, and 37 civilians for a total authorized strength of 86. The average assigned strength was 13 officers, 2 warrant officers, 26 enlisted, and 46 civilians, for a total average assigned strength of 87.

USAARL employs a highly skilled and trained work force with 71 percent of assigned employees possessing degrees. The types of degrees held by Laboratory employees as of 31 December 2001 were: 4 M.D.s, 11 Ph.D.s, 2 O.D.s, 16 Masters, 19 Bachelors and 10 Associate degrees.

Equal Employment Opportunity (EEO) Program:

In CY01, the Fort Rucker EEO Committee and the Human Resources Council were combined into the Human Resources/Equal Employment Opportunity Council (HR/EEOC). USAARL provided a primary representative. Quarterly EEO reports were submitted to the Fort Rucker EEO Office. These reports identified USAARL's EEO objectives; actions taken to meet objectives: and accomplishments in meeting the objectives through hiring actions, promotions, details, or temporary promotions, awards, training, and supervisors' support of the EEO Program. Also in CY01, HQ TRADOC instructed installations to combine their Special Emphasis Programs (Federal Women's, Black Employment, Hispanic Employment, Asian/Pacific Islander, and American Indian/Alaskan Native) under one "umbrella."

Black Civilian Employees: Two black females received an "A" performance evaluation with a pay for performance. One black female received the Commander's Award for Civilian Service and an On-the-Spot Cash Award. As of 31 December 2001, there were 45 civilian employees--3 black females, for a representation of 7 percent.

Hispanic Civilian Employees: USAARL has one male Hispanic employee.

Handicapped Civilian Employees: USAARL has no handicapped employees at this time.

Women Civilian Employees: As of 31 December 2001, there were 20 female employees out of 37 permanent civilians, 3 overhires, and 5 term employees, for 44 percent of the 45 total employees.

Of the 18 female employees rated, 12 received an "A" evaluation and 6 received a "B" evaluation.

Personnel Achievements:

Promotions: The military staff earned 4 promotions in CY01 ranging from E-4 to colonel. The civilian staff had one promotion; a white female was promoted to DJ-0560-3 (GS 11 Equivalent), Budget Analyst.

Awards: USAARL's highly motivated, productive staff was recognized for performance in CY01 with:

Military awards:

Army Good Conduct Medal	2
Army Commendation Medal	5
Army Achievement Medal	15
Legion of Merit	1
Meritorious Service Medal	5
Total	28

Civilian Awards:

Pay for Performance A's	27
Pay for Performance B's	17
Time Off Awards (TOAs)	12
On-the-Spot Cash Awards	8
Initial Invention Awards	3
Superior Civilian Service Awards	2
Commander's Award for Civilian Service	2
Achievement Medals	5
Civilian of the Quarter Awards with TOAs	4
Civilian of the Year Award with TOA	1
Total	81

SCIENTIFIC PROGRAMS

USAARL scientific research encompasses three of USAMRMC's major research areas. They are systems health hazards, hazards of mechanical forces, and combat crew effectiveness. Under each of these research areas, USAARL has established scientific programs which are directed at fulfilling either an Army Science and Technology Objective (STO) or a USAMRMC Science and Technology Execution Plan (STEP).

Titles, the DA Form 1498 accession number, and the USAARL division with the responsibility for these projects are listed below.

TITLE	DA ACCESSION NUMBER	DIVISION
Cognitive Factors and Workload in the Army Aviation Environment	DA0G0151	Aircrew Health and Performance
Coping Strategies for Helicopter Pilots and Crews Involved in Night Operations	DA335655	Aircrew Health and Performance
Enhancement of Aviator Sleep and Performance Through Chemical Intervention	DA336185	Aircrew Health and Performance
The Investigation of Spatial Disorientation and Related Topics	DA336186	Aircrew Health and Performance
Research Countermeasures for Significant Medical Hazards in Military Systems	DA0G0165	Aircrew Health and Performance
Military Visual Performance	DA361539	Aircrew Health and Performance
Military Visual Problems: Assessment, Mechanisms, and Protection	DA0B6893	Aircrew Health and Performance
Visual Performance Issues of Flat Panel Technologies	DA336445	Aircrew Health and Performance
Protective Mask Optical and Visual Assessment	DA346090	Aircrew Health and Performance

Methodologies for Assessing Retinal and Visual Functions	DA336446	Aircrew Health and Performance
Mechanism of Melatonin Action on Military Performance	DA360560	Aircrew Health and Performance
Aviator Status Monitoring	DA361534	Aircrew Health and Performance
Evaluation of Refractive Error Correction Methodologies and Military Implications	DA306074	Aircrew Health and Performance
Crashworthiness of Aviation Life Support Equipment	DA302870	Aircrew Protection
Operational Studies of Aviation Life Support Equipment	DA0G0167	Aircrew Protection
Repeated Impact Tolerance Criteria for U.S. Army Ground Vehicles	DA336192	Aircrew Protection
Develop Criteria, Models and Evaluation Methodologies to Improve Aviator Communication Performance and Hearing Protection	DA360347	Aircrew Protection
Medical Equipment Airworthiness Certification Evaluations	DA361537	Aircrew Protection
Soldier Performance and Injury Based Design Criteria for Mass Properties of Head Supported Devices	DA361535	Aircrew Protection
Conventional Restraint Systems	DA366716	Aircrew Protection
Enhanced Head Protection of Paratroopers	DA366715	Aircrew Protection
Inflatable Restraints	DA366714	Aircrew Protection
Aviation Life Support Equipment Retrieval Program (ALSERP)	DA366713	Aircrew Protection

MANAGEMENT ACTIVITIES

Technology Transfer:

USAARL maintained an active technology transfer program in CY01 through distribution of its technical reports; publication in the open literature; presentations to military and civilian audiences; execution of Cooperative Research and Development Agreements (CRDAs); and membership in federal, regional, and state technology transfer organizations.

Collaborative research resulted in the filing of two patent applications. One of the patent applications is for a software aid for the design of multifunction displays. The other is for a field-ready monocular helmet-mounted display imagery evaluation system. Both inventions are of benefit to Army aviation and have great commercial potential as well. Six invention disclosures were filed, four of which concern speech intelligibility measurement.

USAARL CRDA partners in CY01 are:

Boston Dynamics, Inc. for collaboration in measurements of helmet physical properties.

Communications & Ear Protection, Inc. for collaboration in research, development, test and evaluation of hearing protective devices.

H. Koch & Sons for collaborative research on advanced aircrew restraint systems.

Heartstream Operations (Agilent Technologies) for collaborative research, development, test and evaluation on aeromedical equipment.

ITT Defense for collaborative research in visual testing of image intensifier components and systems.

Johns Hopkins University School of Hygiene and Public Health for collaboration on basic and applied research into the effect of occupational exposure to electric and magnetic fields of 6-OHMS excretion.

L-3 Communications Corporation for collaboration on software support for simulation devices.

Lifesaving Systems, Inc. for research, development, test and evaluation on medical devices for use on U.S. Army aeromedical evacuation equipment.

Medical Plastics Laboratory, Inc. for collaborative research, development, test and evaluation of a manikin designed for use as a medical teaching tool.

Medtronic Physio-Control, Inc. for cooperative research, development, test and evaluation of medical devices for use on U.S. Army medical evacuation helicopters.

Medical University of South Carolina Department of Ophthalmology for collaborative research on visual performance issues in aviation.

Nonin Medical, Inc. for cooperative research, development, test and evaluation of medical devices for use on U.S. Army medical evacuation helicopters.

Oregon Aero Corporation for research on aeromedical safety equipment.

Purdue University for collaborative research in hierarchically-ordered information in intelligent multifunction displays.

Rush Medical Group for development of advanced helmet technologies.

Survivalink Corporation for collaborative research, development, test and evaluation of medical devices for use on U.S. Army medical evacuation helicopters.

T.R.U.E. Research Foundation for cooperative research on the effect of helmet configuration on the head injury incidence rate as experienced by an operational airborne unit.

Troy State University for loan of excess scientific equipment for use by chemistry and biology classes.

University of Florida Institute for Advanced Study of the Communication Processes to collaborate on basic and applied research for evaluating hearing processes, hearing protective devices, and speech communication.

Utah State University Department of Communicative Disorders and Deaf Education to collaborate on basic and applied research for evaluating hearing processes, hearing protective devices, and speech communication.

Zoll Medical Corporation, Inc. for collaborative research, development, test and evaluation on medical devices for use on U.S. Army aeromedical evacuation aircraft.

Science Support Center:

The Science Support Center (SSC) library provided the information necessary to support the aeromedical research performed at USAARL, supported three Flight Surgeon Courses, and disseminated scientific information to requesters worldwide. The library holdings are believed to comprise the most comprehensive aviation medicine collection in this part of the country.

Audiovisual and editorial services contributed to the publication of USAARL technical reports and open literature publications. These services also produced video documentaries, brochures and pamphlets describing the research conducted by USAARL scientists and engineers.

Resources Management:

Program funding for FY01/02 (dollars in thousands):

	FY01	FY02
6.1 Basic Research	250	0
6.2 Exploratory Development	5,314	5,738
Other	836	870
TOTAL	6,400	6,608

Flight Activities:

Aviation research/research support was provided by six active duty Medical Service Corps (MSC) aviators, three Chief Warrant Officers, and two Department of the Army Civilian research pilots/instructors. The majority of the aviators operate at least two of USAARL's platforms for research support.

Assigned aircraft in CY01 were:

JUH-1H - 71-20033
JUH-60A - 88-26069
NUH-60FS - Simulator

Flight hours in USAARL aircraft in CY01 were:

Rotary wing flight hours – 480
JUH-1H – 112
JUH-60 – 368
Simulator flight hours – 391

Simulator and peripherals utilization other than flight – 2,420

During CY01, USAARL aviation assets were used for the following research studies:

JUH-1H - Joint aviator laser eye protection (JALEP), Comparison of the clear laser eye protection to the standard green spectacles, OMNI-V night vision goggle (NVG) evaluation, Airborne manikin head supported mass injury risk, and the Airworthiness Certification Program.
JUH-60A – OMNI-V NVG evaluation, Airborne manikin head-supported mass injury risk, ICIDS airborne certification, Spatial disorientation, Airsickness prevention, Certification of life support for trauma and transport (LSTAT), and the Airworthiness Certification Evaluation (ACE) Program.
NUH-60FS - Navy HAILSS heat stress study, Air warrior heat stress study, Spatial disorientation scenario's, Temazepam, Contact lens, Retinal and visual function, and 100-degree Panoramic NVG.

USAARL made significant strides in the ACE Program during CY01. A tri-service Patient Movement Item (PMI) conference was hosted by USAARL in the spring of CY01

identifying the requirements for a joint airworthiness certification of medical carry-on equipment. The UH-60 fleet wide airworthiness release (AWR) was expanded to include all UH-60A, UH-60L, and search and rescue (SAR) aircraft in the U.S. Army active, reserve, and National Guard. Further testing at Redstone Arsenal, Alabama, vastly reduced the restrictions on the UH-60 fleet-wide AWR. This AWR now includes the Medtronics Physio Control Lifepak 10-59 PMI and 10-62 PMI defibrillators, Alaris IVAC MedSystem III Infusion Pump 2863B and 2865B, BCI 3303GR Pulse Oximeter, Impact 754 Ventilator, Impact Portable Aspirator Model 325M, Impact Portable Suction System Model 326/326M, Protocol Propaq 106EL/206EL Vital Signs Monitors, Unitron Portable Power System, and the 60 hertz Converter Adapter Plate. The first UH-1 fleet wide AWR is awaiting final signatures at AMCOM. USAARL is currently testing the Survivalink Automated External Defibrillator (AED) and Infusion Dynamics I.V. Power Infuser. HH-60L ACE testing is planned for CY02. Also, there are plans for improving the electromagnetic interference (EMI) testing ability at USAARL to meet future requirements.

During CY01, many distinguished visitors, from general officers to foreign officials, were given demonstrations of the USAARL-developed simulator spatial disorientation scenarios, thus enhancing awareness of what the aviator may experience and demonstrating the use of this package as a training tool.

Several significant events affected USAARL flight activities in CY01. The JUH-60 had a scheduled maintenance phase inspection in April and May. In August, the following installations occurred: Mandatory maintenance modifications of the SLAB battery, auxiliary fuel management system, high frequency radio ARC 220, and aviator night vision imaging system (ANVIS)-compatible lower console lights. The JUH-1H had a scheduled maintenance phase inspection in September. Even with this extensive maintenance, the USAARL aircraft still exceeded normal Department of the Army flying hours.

Standardization/Aircrew Training Program: Three aviator personnel turnovers occurred this year. All were experienced aviators, one was an experienced UH-60 aviator and two were flying other than their USAARL assigned primary aircraft. This increased the training workload significantly. Additional workload on the UH-60 occurred when two USAARL assigned aviators went through qualification training. Two aviators attended UH-60 refresher training. Twenty-eight instrument and contact flight evaluations were administered, in addition to 16 no-notice, pilot, pilot-in-command, and instructor pilot

evaluations. Flight Systems continued its role of consulting and coordination with USAARL research divisions in developing and supporting flight and non-flight research protocols.

Flight Systems also was involved in external commitments and consultations with personnel attending or tasked to support the following:

Army-wide Simulation, Training and Instrumentation Command (STRICOM) Synthetic Flight Training Systems (SFTS) Conference
Sparandio Medical Operations Conference
U.S. Army Medical Command (MEDCOM) Aviation Safety and Standardization Council
U.S. Army Aviation Center (USAAVNC) Safety and Standardization Council
Aircraft Logistics Management Division (ALMD) support missions
U.S. Army Aviation and Missile Command (AMCOM) Airworthiness Certification Coordination Meetings
Army Medical Department (AMEDD) Evacuation Integrated Concept Team (ICT)
UH-60 Users Conference (AMCOM)
Defense Advanced Research Projects Agency Spatial Disorientation Workshop
Tri-Service Spatial Disorientation Technical Working Group
U.S. Army Medical Evacuation (MEDEVAC) Proponency
Naval Aviation Systems (NAS) Patuxant River
U.S. Army Aviation Technical Test Center (ATTC)
Program Manager, Aircrew Integration System (PM ACIS), Air Warrior Program
Navy Aeromedical Research Laboratory (NAMRL)

Training:

USAARL's training program for CY01 included 47 training experiences. Training encompassed supervisory development training, software training, training required by Equal Employment Opportunity mandates, and training to assist employees to perform more effectively in their current positions.

Computer Information

For several years, USAARL has desired to have the MARS building networked into our base local area network, but this project had not been feasible due to technology and cost constraints. This year, however, the building was added to USAARL's campus area network (CAN). Using existing phone line copper, the project cost was completed for

less than $5000 dollars and added 12 ports of high-speed connectivity. This significantly increases the functionality of the MARS lab by allowing personnel working in that area to maintain network-based communications and also promotes improved data management by establishing a portal for high-speed and reliable data transfer to USAARL network backup devices.

USAARL has taken major steps in its analog to digital transformation. In conjunction with the Secretary of the Army's Directive #2—Written Communication, USAARL has instituted a digital distribution policy for its written products. This program exploits the rapid and inexpensive use of electronic media distribution verses traditionally slower and much more costly physical production. Additionally, USAARL launched its conceptual digital document centers. These document centers provide one-stop service for high-speed print, copy, scan, and fax requirements. Integrated into the hardware is automatic, high-speed scanning to the industry-standard electronic format, Acrobat, and full-integration into the Exchange mail network. This promotes document scanning and distribution electronically rather than through traditional mail systems.

USAARL has turned its focus to the value of its research and business data. Realizing that research data can sometimes represent near-unrepeatable experiments worth thousands of dollars, we have begun implementing centralized high-speed data backup services. These backup shares collect system and user data and soon will be moved off-site to enhance disaster-recovery plans. Another by-product of this system is that we promote and enhance knowledge transfer by moving data from personal shares and local drives to more accessible network systems.

USAARL is now in the advanced implementation of its Windows 2000 migration. We have successfully converted over 50 percent of our workstations to the new desktop operating system. The application environment is proving to be stable and much more robust than the former Windows 9X operating system. The key improvement, however, is security. Legacy application conversion and modification will continue, and we project a complete migration in 2002.

USAARL has significantly increased its information systems security posture. In 2001, many IT man-hours were committed to attaining compliance with documented security threats to both systems software and hardware. Internally, we have improved our systems to insure we preclude individual system compliance oversights. We also have established systems that automate many of the compliance requirements, saving valuable IT man-hours.

RESEARCH ACTIVITIES

Aircrew Health and Performance Division:

Aeromedical Factors Branch:

Aircrew Endurance and Sustainment

Sleep deprivation, fatigue, reverse cycle shifts, and other work-related stressors degrade aviator performance, potentially causing serious problems with regard to safety and effectiveness. In order to analyze when aviators work, how frequently they rotate shifts, and how well they sleep when working nights, a survey was conducted to address the effects of reverse cycles. This survey showed that almost all aviators have worked reverse cycle at some point in their career. Based on the lack of restful sleep in these aviators, it was determined that further research was needed to find various ways to help crews adjust to working reverse cycle and its effects on performance. The ability to predict oncoming performance decrements would enable commanders to implement appropriate countermeasures; however, the only viable methods for making such predictions involved tests that distracted the pilot from his primary job of flying the aircraft. The implementation of real-time electroencephalograph (EEG) monitoring avoided distracting the aviators because of the unintrusive nature of this approach. The use of this real-time EEG has allowed monitoring of pilots' general fatigue levels during actual helicopter flights without interfering with their primary duty of flying the aircraft. These data show both cognitive and mood decrements associated with the fatigue from sleep loss in laboratory and in-flight settings.

In order to sustain mental performance in this situation, the short-acting hypnotic, temazepam, was successful at prolonging daytime sleep an average of 1.5 hours over placebo. This extended daytime sleep led to a longer period of subjective alertness and longer performance during the night shift compared to placebo. Occasionally, Army personnel buy and use over-the-counter (OTC) substances to help with various symptoms of cycle shifts. Melatonin may be used by some Army aviation personnel for help in adjusting to reverse cycles. A frequent concern from the sleep medicine community is that OTC melatonin may contain impurities and its content is not well controlled. Analysis of six brands of OTC melatonin tablets indicated a high variability in the actual

content of melatonin compared to the label dosage. Due to this high variability in actual melatonin content of OTC preparations, it is doubtful that these preparations can be relied upon for accurate dosages for research.

Crew Coordination

Over 70 percent of rotary-wing accidents can be attributed, at least in part, to human error. Over half of these accidents involve at least one crew coordination failure. These failures typically involve poor coordination of actions due to miscommunication or no communication among the aircrews. Unfortunately, these mishaps continue to plague the military community.

The Duo WOMBAT-CS is a computerized test that measures situational awareness, stress tolerance, attention management abilities of complex-system operators and crew resource management in a team environment. This test is a derivative of the WOMBAT-CS, which is designed to measure a single operator's performance. In the Duo WOMBAT-CS, various tasks will be shared between teammates with the emphasis placed on cooperation not competition. A participant's ability to manage a complex system is measured by presenting situations and evaluating the reaction to those situations. The situations presented enable the researcher to evaluate performance in the following areas: attention to multiple information sources, evaluation of alternatives, establishment of priorities, estimation of probable outcomes for different courses of action, attention to the highest moment urgency without disregard for the routine tasks, reestablishment of priorities as situations deteriorate or improve, and decisive action in the face of indecision of others. The Baseline Duo-WOMBAT Performance study will examine the pilot team's performance on a test with elements relevant to situational awareness and crew coordination. The baseline data obtained benefit the situational awareness work in general by enabling the Duo-WOMBAT to be used in future studies which will be designed to meet specific situational awareness and crew coordination milestones.

Situational Awareness Research

Past research has suggested that a minimum of 32 percent of U.S. Army rotary-wing accidents have spatial disorientation (SD) as the major causative factor - and that the rate may be higher in combat. This research must be updated to identify areas for further research, evaluate investigation and data recording methods for SD accidents, and

recommend potential solutions. Spatial Disorientation Accident Analysis research indicated the number of accidents in which SD was implicated by comparing accidents involving SD with other accidents in order to determine particular patterns associated with SD accidents. In particular, night accidents were assessed. This review is providing information about the human factors issues involved in rotary-wing accidents. These will be more closely examined following full data analyses. Concerning prevention of accidents, SD training demonstrated that instructor pilots, given appropriate training, could provide adequate demonstrations and physiological explanations of the flight maneuvers and conditions most likely to create disorientation. Use of flight instructors to provide this information has freed the flight surgeons from this duty and made training more flexible. Several SD videos and CDs have been requested. Furthermore, a questionnaire was given to a minimum of 100 aviators to determine the demographics of Army aviators who use, have used, or do not use the USAARL-developed SD Awareness Training Scenarios as part of their simulator training requirements. Particular emphasis was placed on whether the SD Awareness Training Scenarios have improved the aviator's ability to recognize those factors that lead to SD. The results showed (1) over 90 percent of respondents felt that all aviators would benefit from this training; (2) approximately 72 percent of respondents felt that this training improved overall situational awareness and air crew coordination; (3) sixty-seven percent indicated that this training improved decision making abilities; and (4) three aviators reported that this training had actually prevented them from having a mishap/accident when faced with a disorienting situation.

The head-up display (HUD) superimposes flight symbology on one tube of the Aviator Night Vision Imaging System (ANVIS) so that no head movement is required in order to obtain flight information. Overall, it is commonly felt that this addition has decreased pilot workload. However, past research has shown that some aviators experience more severe episodes of spatial disorientation while using the HUD. Aviators complain about the ANVIS-HUD because it has nearly a full second lag in visual refresh rates and can impact spatial awareness. A comparison was made between the older version 1 versus the newer version 3 to see if the faster refresh rate may prevent spatial disorientation following entry into instrument meteorological condition (IMC). Initial analysis showed that more aviators failed to recover from inadvertent entry into IMC with the slower version 1, indicating the refresh rate is too long in version 1. Also, a survey was designed to collect opinion and usage data from 100 U.S. Army aviators. The responses have been collected and data will be analyzed to establish normative settings used by aviators under specific flight conditions (hover, low level, etc).

Environmental Aeromedical Research

Over the past five years, USAARL has tested various configurations of mission oriented protective posture (MOPP) ensembles for the Air Warrior program. These past efforts have examined the effects of thermal stress on aviator performance while fully encumbered in MOPP4. Previous studies have examined flight performance for periods of up to 4 hours. Due to extended mission requirements in the rotary-wing community, the current study will extend the evaluation period to 5.3 hours. A within-subject design will be used to gather physiological and flight performance data during three conditions: 1) Unencumbered, no heat; 2) Fully encumbered, no heat; and 3) Fully encumbered with heat. The objectives of this study are to assess the safety of the full MOPP ensemble with personal cooling during extended operations in a thermally stressful condition and to examine the effects of this ensemble on flight performance.

Visual Sciences Branch:

Mechanism Assessment of Military Visual Problems

As part of USAARL's core mission, optical systems were evaluated to determine the impact on visual performance of various design characteristics. Observation flights were used to evaluate two prototype Air Force laser protective visors and two types of laser protective spectacles, with and without side shields. Visual tests with and without the seven-notch Navy spectacle laser protection with the Aviator Night Vision Imaging System (ANVIS) were jointly conducted with the U.S. Army Aviation Technical Test Center (ATTC). The vertical and horizontal locations of the eyes were measured with 90 participants using mechanical methods during the user evaluations of the prototype Military Eye Protection System (MEPS) spectacles and goggles. Any modifications to the frame may significantly affect absolute eye locations, which are critical to the laser eye protection performance. Additionally, the research team evaluated an explosive ordnance faceshield from Natick Laboratories.

USAARL serves as the Army's primary site for assessment of night vision goggles in the Army aviation environment. This year, studies were conducted to evaluate the ANVIS head-up display (HUD) mock-ups on ANVIS compatibility and ANVIS performance for PM-NV/RSTA. A project was completed to determine the feasibility of using the AN/PVS-14 monocular night vision device (MNVD) for pilotage. In a high light, night condition, study showed that pilots could fuse the unaided eye and image intensified

images using a single tube image intensifier, and the fused image provided some color and depth perception. Under low light, night conditions, pilots preferred a binocular system. Laboratory, flight and simulator assessments of an earlier version of the Panoramic Night Vision Goggle were conducted at USAARL. OMNI-V, V3 ANVIS and OMNI-IV goggles were evaluated to determine temporal responses to changing light levels.

Refractive Error Correction Methodologies and Military Implications

Eventually, presbyopic changes force all aviators, even those who have never worn glasses or contacts, to use a correction in order to see their flight controls and read approach plates and maps. Single vision contact lenses only correct distance vision; therefore, the aging aviator must now adapt to these changes by reverting to bifocal spectacle wear. With advances in bifocal contact lens design, it is possible that the level of visual and operational performance may be better than previously found. Studies of the new generation of bifocal contact lenses could ultimately lead to recommended fitting procedures and clinical tests that might be relevant to determining levels of visual performance required for flight. A study of the next-generation bifocal contact lenses is in development.

An inability to meet Flying Duty Medical Examination (FDME) vision standards is the primary cause for flight applicant medical disqualification. Refractive surgery offers an option to correct the refractive error of potential applicants, thereby increasing the applicant pool for Army aviation. Additionally, refractive surgery may reduce the aviator's dependence on spectacles or contact lenses in the cockpit, decreasing the problems of instrument and protective equipment interface (such as head-mounted displays and protective masks). USAARL scientists initiated a large study of flight applicants who have had refractive surgery to determine the impact on visual performance and overall flight performance of initial entry rotary-wing (IERW) candidates. The study further seeks to explore whether there are any situations in which there is an advantage to having had refractive surgery (due to the individual's decreased dependence on spectacles or contact lenses) or whether there are any situations in which there is a disadvantage to having had refractive surgery (low light, low contrast flight situations). Based on the success of this effort, the U.S. Army Medical Materiel Agency (USAMMA) initiated consideration of a Corneal Refractive Surgery Surveillance program for other categories of flight personnel (flight medics, flight surgeons, and air traffic controllers).

Diagnostic techniques to determine the quality of vision after any ocular surgery are also important. The ORBSCAN system uses a set of scanning slits to measure the curvature of the corneal surfaces and the corneal thickness. The accuracy of this corneal mapping system is being assessed in order to verify the information provided to model and assess corneal optics. Wavefront systems will be used in a study of aviator applicants who have had refractive surgery. Very few studies of norms for higher order aberrations have been performed, and those that have been completed include a fairly wide range of ages and refractive errors. USAARL scientists have been working to further establish the norms of ocular aberration instrumentations for individuals who have very little refractive error and are generally less than 30 years of age. Several scientific presentations, technical reports, and open literature manuscripts on visual performance and ocular parameters after refractive surgery were completed.

Military Visual Tests and Retinal Function

Selection and retention of aviation personnel is based on acceptable performance on a number of vision tests. While visual acuity remains the cornerstone of vision assessment, subtle visual loss can escape detection with standard measures of acuity. Efforts are under way to modify the Small Letter Contrast Test developed at USAARL for use in a backlit chart set-up and to incorporate the test into all refractive surgery visual performance studies (Navy, Air Force, and Army cooperative process). Another measure of retinal and neural function is color contrast sensitivity. A viable test developed as a result of this research effort has shown clinical applicability for a number of visual and ocular conditions including glaucoma, multiple sclerosis (neural damage), and macular conditions.

Visual Performance with Electro-Optical Displays

Flat panel displays are being used with increasing frequency in various settings. Several flat panel displays are under development for military applications. Despite obvious advantages of flat panel displays, such as reduced weight and low power consumption, little attempt has been made to assess the visual performance of flat panel systems. Limitations should be identified during development so that future systems afford maximum performance and safety on the battlefield. A paper addressing the need for developing new figures-of-merit for flat panel technology displays was written. A project

is now under way for the development of visual tasks that can be used for performance assessment on flat panel and helmet mounted displays.

The U.S. Army is fielding the next generation attack helicopter, the RAH-66 Comanche. This helicopter uses an advanced helmet mounted display (HMD) system. This HMD, known as the Helmet Integrated Display Sighting System (HIDSS), currently employs liquid crystal display (LCD) technology. The Program Manager-Aircrew Integrated Systems (PM-ACIS) is also investigating an alternative source and HMD configurations. Proposed HMD systems are employing a partial binocular overlap. This approach may degrade visual performance, especially target detection, and introduce visual artifacts. These technologies and systems are being evaluated at USAARL for impact on pilot performance.

Advanced cockpit designs are moving away from dedicated cockpit instruments toward multifunction displays (MFDs). How the information is presented to the pilot in terms of ease of access and logical sequencing will affect how well the pilot can use the information presented in an MFD. Research has been completed to evaluate a modeling system to improve the sequencing and access of information in MFDs.

To provide subject matter expertise to British flight surgeons supporting the fielding of Apaches in the British Army and to assist in a longitudinal evaluation of pilots transitioning to or beginning duty in the Apache aircraft, USAARL initiated a collaborative effort with the British Army in fielding the Apache Integrated Helmet and Display Sighting System (IHADSS) HMD.

Aircrew Protection Division:

USAARL's Aircrew Protection Division (APD) comprises a team of engineers, aviators, and health care professionals. The team studies the effects of exposure to physical forces (e.g., impact decelerations, repeated impact, jolt, and noise) on the health and performance of Army air and ground warfighters. It studies communication performance and causes of injury and attrition. These efforts are accomplished through epidemiological research, computer modeling, laboratory simulation, use of crash manikins and human volunteers, investigation of mishaps, and study of combat crew life support equipment. Team members recommend injury prevention strategies to equipment developers and major commands.

Airworthiness Certification Evaluation (ACE)

Under the aegis of the ACE program at USAARL, airworthiness certification was granted in CY01 for 10 items of medical carry-on equipment for use aboard UH-60A medical evacuation (MEDEVAC) helicopters. ACE testing was also completed aboard UH-60L search and rescue (SAR) and UH-1 helicopters and a fleet-wide airworthiness release (AWR) is underway for those airframes. Evaluation of the life support for trauma and transport (LSTAT) system was completed aboard the UH-60A and UH-60L SAR aircraft and AWRs (by tail number) for different MEDEVAC units were granted. Currently, the ACE laboratory is testing eight items of medical carry-on equipment.

Standard For Health Hazard Assessment of Repeated Jolt in Army Vehicles

A research program to document human whole-body response to repeated jolt has been conducted at USAARL over the past few years. The original research, which was performed under contract with British Columbia Research Inc., established new safe tolerance thresholds that were previously considered hazardous. The effort resulted in a new model for health hazard assessment of repeated shock. The adoption of this model as a standard methodology will allow Army health and industrial hygiene professionals to evaluate, with more confidence than previously possible, Army tactical vehicles for exposure to whole-body vibration containing repeated shocks. A study is underway at USAARL to compare the new methodology to previous assessment methods using data

collected from actual Army tactical vehicles. The assessment method and software used to apply this new standard will then be transitioned to Army developers and health professionals for future use.

Aviation Life Support Equipment (ALSE)

In CY01, USAARL life support equipment researchers discovered a discrepancy in the shell of the recently fielded HGU-56/P aviation protective helmet. This discovery expanded to a review of local Army aviation assets, as well as an Army-led quality control assessment of manufacturing techniques. The initial discovery has led to revised helmet inspection criteria, preserving the safety of Army aviation flight crews. USAARL engineers were instrumental in testing and advising the Army regarding the fitness of a new infantry boot for use in the aviation environment. The issues of thermal protection and permeability protection were pivotal.

Aviation Life Support Equipment Retrieval Program (ALSERP)

The ALSERP has evaluated all available safety and protective equipment involved in causing or preventing injuries in U.S. Army and other aviation accidents. Researchers have delivered reports identifying failings in helmets, harnesses, seating, and procedures and have recommended solutions and promoted further research. Investigation and analysis of aviation night vision imaging system (ANVIS) breakaway mountings have led to verifying military performance requirements and circumventing a costly inspection and modification program. Our ongoing expert assistance to other services and government agencies has contributed to the development of a safer working environment in those organizations.

Cockpit Air Bag System (CABS) Research Program

In CY01, cockpit air bag research focused on determining the risk of facial and/or ocular injury due to night vision goggles (NVGs) being propelled rearward into a cockpit occupant's face by a deploying air bag. Evidence of this injury mechanism was seen during dynamic qualification tests of the OH-58D Kiowa Warrior cockpit air bag system in which deploying air bags forced NVGs rearward into the eye/orbit region of both a 50th and a 95th percentile test manikin. Most crash test manikins are not equipped to

measure contact loads to the face, and even if they were, no criteria currently exist for assessing the risk or determining the severity of facial and/or eye injury due to air bag induced NVG motion.

USAARL contracted with the Automobile Safety Laboratory at the University of Virginia to develop risk functions for eye injury or bony orbit fractures and to use this risk function to assess the risk of injury. The primary focus of the work has been on the aviation-specific problem of helicopter cockpit air bag interaction with NVGs. Four live air bags were deployed into four instrumented, NVG-wearing biological specimens. These tests showed that eye injuries appeared to correlate with head acceleration, rather than globe distortion or blunt trauma. Upcoming work will evaluate protective devices, and identify determinants of injury risk such as anthropometry and cockpit geometry.

Acceleration Injury Assessment: Crash Manikin

Health hazards encountered in Army systems include whole-body accelerations and blunt impacts that can produce skeletal and internal soft tissue injuries. One way that USAARL assesses these hazards is by using crash manikins and anthropomorphic test devices that faithfully reproduce the human biodynamic response to impact. When subjected to impact tests, data from these devices are processed and evaluated to estimate the risk of injury to the exposed soldier. USAARL has developed a manikin with internal data acquisition system (MIDAS) to assess impact response. In 2001, USAARL conducted manikin tests on the Fort Benning, Georgia, swing landing trainer and 34-foot towers, typically used to train soldiers in the techniques for airborne static line parachute jumps. The manikin was configured with helmets having different head borne weight conditions to induce inertial transmitted neck loads during the landing fall and riser snap events. Over 120 exposures were completed within a 4-day study period. Subsequent to this effort, actual parachute drops where conducted with the instrumented manikin from a UH-60 Black Hawk helicopter. These studies were conducted with a standard T-10 circular parachute. The MIDAS was able to record opening shock loads as well as landing fall impacts in the same data capture event. Over 150 jumps were executed with the manikin during this effort. These studies have already provided important safety data to the Army airborne community and will help predict the risk of neck injury with future head-supported technologies in this demanding environment.

Biomedical Design Criteria for Helicopter Auditory Displays

The USAARL acoustics laboratory is beginning a new Science and Technology Objective which will define the biomedical design specifications required to allow all Army rotary-wing aviators to use virtual (3D) auditory displays. Research suggests that auditory displays proposed for use in Army rotary-wing aircraft may not be perceived correctly by aircrew members whose auditory end-organs have been damaged by exposure to intense noise. The purpose of this research effort will be: (1) to evaluate new auditory display technologies (virtual [3-D] auditory displays and auditory icons) for use by hearing-impaired listeners in noisy environments and (2) to provide developers of these technologies with medically-based design criteria to ensure effective display use by Army aviators operating in noisy environments. The objective of this program is to enhance the safety and operational mission capabilities of future Army warfighters, regardless of hearing profile, using improved auditory displays.

Contracts:

Through sponsorship by the U.S. Army Medical Research and Materiel Command, USAARL maintains an extramural research program in support of its in-house research. These research contractors perform at their own facilities and, in some cases, onsite at USAARL, where unique research tools and facilities can be provided at lower cost to the Army.

Present contract efforts include:

- High-impedance, Dry Physiological Recording Optrode, Phases I and II; SRICO, Inc. Principal investigator – Dr. S. A. Kingsley.

- Contributive Research in Aviation Medicine, Bioengineering, Human Performance, Analytic and Modeling Systems and Data Management, Universal Energy Systems, Inc. Principal investigator - Dr. Thomas Harding.

- Low Cost Virtual Reality System for Monitoring Pilot Performance During Simulated Helicopter Flight, Phase I, Systran Federal Corporation - Mr. G. Valentino.

- Solid State Compact and Rugged Personal Environmental Recording System Employing Inertial Sensors and Electromyographic Monitoring. Physical Optics Corporation – Dr. Stephen Kupiec.

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2001-05. **Visual Search Performance in HMDs With Partial Overlapped Binocular Fields-of-View.** June 2001. *(ADA392013)*
By Victor Klymenko, Thomas H. Harding, Howard H. Beasley , and Clarence E. Rash

2001-06. **Final Phase One Evaluation of the Microvision, Inc. Aircrew Integrated Helmet System (AIHS) HGU-56P Scanning Laser Display.** June 2001. *(ADA392525)*
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2001-08. **Use of Simulator Spatial Disorientation Awareness Training Scenarios by the U.S. Army and National Guard**. July 2001. *(ADA395082)*
By Arthur Estrada, Gina E. Adam and Patricia A. LeDuc

2001-09-NP. **USAARL Research Series: Night Vision Goggles 1975-2000**. July 2001. *(ADM001315)*
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2001-11. **Rotary-Wing Airworthiness Certification Evaluation of the BCI International 3303 Pulse Oximeter, Part A: Laboratory Testing**. August 2001. *(ADB271170)*
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By Keith L. Hiatt, Malcolm G. Braithwaite, John S. Crowley, Clarence E. Rash, Corina van de Pol, Daniel J. Ranchino, William K. Statz, and Allison J. Eke

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Technical Memoranda:

Subject: Whole-Body Vibration Health Hazard Assessment Request, Health Hazard Assessment Report on the Deployable Universal Combat Earthmover
Customer: USACHPPM

Subject: Health Hazard Assessment Report on Rough Terrain Container Handler
Customer: U.S. Army CHPPM

Subject: HHA on the Modular Causeway System Warping Tug
Customer: U.S. Army CHPPM

Subject: Comments on GESAC Cost Proposal for Army-Specific Thor Alpha
Customer: U.S. Dept of Transportation, Nat Hwy Traffic Safety Admin

Subject: Cockpit Air Bag System (CABS) Research Studies
Customer: PM-ACIS

Subject: USAARL'S Input to the Cockpit Air Bag System Health Hazard Assessment
Customer: U.S. Army CHPPM

Subject: ALSERP Analysis of Case 01020708240067301
Customer: U.S. Army Safety Center

Subject: A/C Accident Investigation ALSERP Analysis of USASC Case 010116200509426564
Customer: U.S. Army Safety Center

Subject: ALSERP Interim Report on USASC Case UH-60 Mid-Air Collision
Customer: U.S. Army Safety Center

Subject: USAARL Problem Fit Program, HUG-56/P Helmet "Soft Spot" Survey, 31 May 01 and 5 Jun 01
Customer: PM-ACIS

Subject: USAARL'S Response to Discrepancies Reported in TM 01-01
Customer: PM-ACIS

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Subject: Brief Assessment of the BAE ANVIS I-HUD Display Unit (DU) Mock-up
Customer: ATB Commander

Subject: Diopter Eyepiece Focus Value for a Fixed Focus Night Vision Device
Customer: NV/ESD

Subject: Analysis of the Luminance and Chromaticity Effects of a Holographic Laser Eye Protective Technology
Customer: PM-ACIS

Subject: Follow-Up Assessment of the COSSI Flat Panel Display Unit Mock-ups
Customer: PM-NV/RSTA

Subject: A Limited Assessment of the Visual Field Blockage from the Integrated Heads-Up Display Housing of the Advanced Night Vision Goggle Mock-up
Customer: NV/ESD: ATTN: AMSL-RD-NV-ASB

Subject: Night Vision Goggle (NVG) Evaluation of OH-58C Test Instrument Lighting
Customer: AMCOM

Subject: An Exploratory Optical Assessment of Candidate Face Shields for the Explosive Ordinance Disposal Suits
Customer: U.S. Army Soldier and Biological Chemical Command

Subject: Preliminary Results, User Evaluation of OMNI V,
Customer: PM-NV/RSTA

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Subject: Fatigue in Aviation
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Subject: Safety Stand Down Day
Customer: DynCorp

Subject: Aviation Life Support Equipment, Survival and Responsibilities of the Flight Surgeon
Customer: U.S. Army School of Aviation Medicine, Army Flight Surgeon Course

Subject: Career Program 12
Customer: U.S. Army Safety Center

Subject: Aviation Life Support Equipment Retrieval Program and Survival
Customer: Missouri Army National Guard Annual Safety Stand-Down

Subject: Aviation Life Support Equipment Retrieval Program
Customer: DOD/ U.S. Army Safety Center

Subject: Aviation Life Support; Real World Successes and Failures
Customer: Nebraska Army National Guard

Subject: Army ALSE Successes and Failures
Customer: U.S. Army ALSE Conference, Huntsville, AL

Subject: NVG Use in Fighter Aircraft
Customer: F/W 114th South Dakota Air National Guard

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